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DISTRIBUTION OF FRESH-WATER GASTROPODS IN RELATION TO TOTAL ALKALINITY OF STREAMS

By C. S. Shoup [1]

During four summers (1938–1941) the biological survey parties of the Tennessee Division of Game and Fish have collected specimens of aquatic mollusks as a part of the fisheries survey work. Lists of some of the species taken have already been published, (Shoup and Peyton, 1940; Shoup, Peyton and Gentry, 1941) and Mr. Calvin Goodrich, who kindly identified the specimens, has already reported (1940) on the sequence of distribution of our species from the Obey River drainage of Tennessee.

At the present time 47 of the most abundant species of gastropods have been obtained from 156 localities out of a total of 420 different collecting stations in the minor watersheds of the principal drainages of the state. Most tributaries from which collections have been taken, particularly in the basin of the Big South Fork of the Cumberland, the Obey River, and nearly the whole of the Tennessee drainage in East Tennessee, flow over bedrock characteristic of a particular geological formation, and in many instances discernible differences in total alkalinity, usually as bicarbonate (acid carbonate) alkalinity, can be definitely assigned to the presence of a particular bedrock stratum characteristic of the individual stream. We have been interested in this geochemistry of the natural waters, and I have attempted to

[1] Department of Biology, Vanderbilt University.

show here our findings regarding distribution of various species of snails in waters of definite degrees of total alkalinity, and what we have discovered thus far regarding the apparent productivity in terms of frequency of snail collections in the numerous stations of different alkalinity limits.

It has generally been assumed that with aquatic mollusks carbonate and bicarbonate in solution in fresh waters produce a more favorable environment than very soft waters having no appreciable hardness. This has been partially indicated by Adams (1915, p. 47) and by Boycott (1936, p. 148), but as the latter author indicates, the great trouble is to disentangle the importance of quality of water from geographical distribution, the physical characters of the habitat, and available food materials as factors promoting abundance of a species at any locality. I have not considered, in our tabulation of distribution, the abundance of a species, but rather the presence of particular species. For the most part, the more alkaline streams yielded greater volume of collections of each species present. The final effect of ecological factors is their sum and the beneficial effect of calcium in many localities may be overridden by other unfavorable circumstances. Nevertheless, if enough collecting is carried out in sufficient numbers of localities, with simultaneous determination of hardness or total alkalinity, one should obtain some kind of picture of distribution of species in the soft-water and hard-water streams.

Few reports on collections give chemical characteristics of natural waters at the time the collections were made. The New Hampshire stream survey reports (Hoover, 1938; Warfel, 1939) show *Campeloma*, *Physa*, *Lymnaea*, and *Helisoma* have been obtained from the very soft waters of that region, while in New York (1936) *Campeloma decisum* and *Pleurocera acuta* appear in waters of moderate alkalinity. On the basis of our present records of the chemistry of natural waters in Tennessee, I cannot see any disagreement in our tabulation of species distributed in various alkalinity ranges with those previously reported by Goodrich (1928, 1934, 1935, 1937, 1938) for Tennessee.

Table I indicates distribution of our collections in relation to total alkalinity as determined by methyl-orange titration at the time of collection and at the site of collection. This shows, ac-

Table 1. Range of distribution of species in waters of total alkalinity as shown in parts per million $CaCO_3$.

Goniobasis clavaeformis	5–220
Goniobasis proxima	6– 8
Goniobasis emeryensis	7– 12
Campeloma decisum	7–135
Goniobasis gerhardtii	9– 13
Campeloma lewisii	10– 20
Helisoma anceps	11– 35
Pleurocera curtum	17– 19
Goniobasis interrupta	17– 25
Pleurocera modestum	17– 50
Pleurocera parvum	17– 85
Anculosa subglobosa	17–165
Goniobasis laqueata	17–179
Physa microstoma	21–180
Lithasia verrucosa	22– 25
Lymnaea columella	22– 34
Physa gyrina	22– 34
Pleurocera canaliculatum undulatum	24–198
Goniobasis angulata	35–165
Physa pomila	41– 45
Pleurocera canaliculatum filum	55– 75
Anculosa praerosa	56–198
Lithasia geniculata pinguis	60– 65
Pleurocera alveare	63–117
Lithasia armigera	63–113
Lithasia geniculata	63– 90
Campeloma ponderosum	63– 70
Somatogyrus depressum	70– 75
Goniobasis ebenum	70–100
Lithasia obovata	80–161
Lithasia armigera stygia	89– 92
Lithasia geniculata venusta	89–106
Lithasia obovata f. depygis	89– 93
Lithasia obovata sordida	99–145
Lymnaea obrussa	100–125
Goniobasis carinifera	105–110
Pleurocera striatum	110–115
Goniobasis teres	113–115
Pleurocera walkeri	116–118
Pleurocera nobile	116–120
Pleurocera unciale	116–220
Anculosa umbilicata	130–135
Goniobasis plicatostriata	134–199

TABLE 1.—(*Continued*)

Goniobasis acutocarinata	139–142
Goniobasis arachnoidea	160–164
Lymnaea humilis modicella	178–182
Physa integra	208–220

cording to our present records, that there may be a tendency for certain species to be restricted to hard or soft waters, while others are well-distributed chemically, but locally restricted in certain drainage areas. Of the Pleuroceridae, *Goniobasis laqueata* and *G. clavaeformis*, for example, are found in a wide range of total alkalinity, but separated in distribution; the former being taken by us mainly in the Ordovician streams of Middle Tennessee, and the latter from the upstream drainage of the Tennessee River in East Tennessee. Many more upland streams with extremely soft water were examined than those with considerable bicarbonate or even normal carbonate in solution. Some of the torrential non-calcareous streams could be discounted as productive on the basis of physical factors, but so many were of suitable ecology with a fair bottom fauna other than snails that the value of only 10.2 percent (Table 2) quite indicates the low productivity of streams below 20 parts per million of bicarbonate.

Certain soft-water streams of the Cumberland Plateau are as low as 2–6 parts per million bicarbonate, flowing in the sandstones

TABLE 2. Distribution of Collections in relation to Total Alkalinity.

Range of Total (M.O.) Alkalinity p.p.m.	No. of Collection Stations	No. of Stations yielding snails	Percentage of productive Stations	Collecting Stations of carbonate (CO_3) alkalinity
0– 20	175	18	10.2	0
20– 40	41	18	43.6	1
40– 60	22	12	54.5	0
60– 80	18	10	55.5	0
80–100	22	15	68.0	4
100–120	33	19	57.5	9
120–140	46	21	45.5	8
140–160	26	19	73.0	3
160–180	16	12	75.0	1
180–220	21	12	57.0	3

and shales of the Pennsylvanian (Lee formation), with no available calcium for shell-building. Such waters were found to be very unproductive. At the other extreme of hardness of 160–220 parts per million total alkalinity, sluggish lowland streams which otherwise might be most productive of snails may be made adverse by intermittent flooding and by movement of deposits of erosion silt, since for the most part their flow is through cultivated land.

It would be of interest to study further this possible relation of species distribution to water hardness in other regions. Possibly this field evidence of the influence of total alkalinity can supplement experimental studies on the quantity of bicarbonate or carbonate necessary for growth and shell building.

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